High Magnesian Dippsodote Dykes in the Oman Ophiolite : Evidence for High Temperature Hydrothermal Circulation in the Oceanic Mantle

著者	Python Marie, Ceuleneer Georges
journal or publication title	Promotion Envirnmental Research in Pan-Japan Sea Area -Young Researchers' Network- : Abotract
page range	124-125
year	2006-03-08
URL	http://hdl.handle.net/2297/6560

High Magnesian Diopsidite Dykes in the Oman Ophiolite: Evidence for High Temperature Hydrothermal Circulation in the Oceanic Mantle.

Marie PYTHON[a] and Georges Ceuleneer[b]

(a) Faculty of Sciences, Department of earth sciences, Kanazawa University, Kakuma-machi, Kanazawa, Ishikawa, 920-1192, JAPAN
(b) Observatoire Midi-Pyrénées, UMR5562, 14, avenue Édouard Belin, 31400, Toulouse, FRANCE

In the mantle section of the Oman ophiolite, mafic and ultramafic veins and dykes are ubiquitous, they are generally interpreted as fossilized melt migration structures that fed the gabbroic crust. Their petrographical and geochemical characteristics are well explained by a crystallization from a common silicate melt (MORB, andesites, boninites). In the frame of a global survey of these relics of melt migration (see Python and Ceuleneer, 2003), we have discovered a peculiar lithology made essentially of almost pure magnesian diopside (Mg number being included between 0.94 and 1.0) which characteristics do not match a magmatic origin.

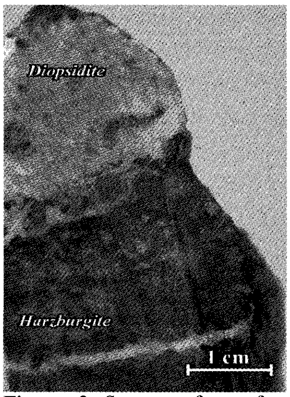

Figure 2 Sawn surface of a sample of harburgite containing few veins of diopsidite showing the progressive contact between veins and the surrounding peri-dotite.

These features are relatively common in the mantle section of the Oman ophiolite but were neglected by the previous workers probably because of their confusing similarity to weathered gabbroic dykes. On the field, they appear as whitish to pale greenish veins and/or dykes of highly variable width (see figure 1) and a freshly broken sample show a fibrous aspect that strengthen the resemblance with saussuritized gabbro. Their mode of occurrence is quite variable, they outcrop frequently as dykes or veins (former cracks) or in brecciated fault zone. When not faulted, contacts with host peridotite seem sharp due to the high contrast in color between the two type of rocks but in details, it is rather progressive and a narrow zone is present at the rim of the dyke where both olivines and diopsides may be observed together. In that case, diopsides replace serpentinized mantle minerals: ghost of former coarse olivine grains are observed at the dyke rim.

Textural and compositional characters are evidences against a magmatic origin for these diopsidite dykes. As most omanese dykes show mosaic, adcumulate or poikilitic textures characteristic of the crystallization from a magma, diopsidite facies exhibit fibrous aspect with large elongated crystals or euhedral needles of diopside crystallizing within a matrix of fine grained diopside. Euhedral diopsides occur inside areas containing hydrous and fibrous serpentine and chlorite (figure 2); on the other hand, carbonate veins may be observed in diopsidite dykes and their relationships with their host is ambiguous. Huge grains of diopside are broken and crossed by the carbonate but small euhedral grains of diopside have crystallized from the rim and/or in the middle of the vein (figure 2) suggesting that the formation of the carbonate vein was contemporaneous with the diopside crystal-lization. These textural observations point to a genesis process by metamorphic growth in a matrix of serpentine and/or carbonate rather than magmatic differen-tiation.

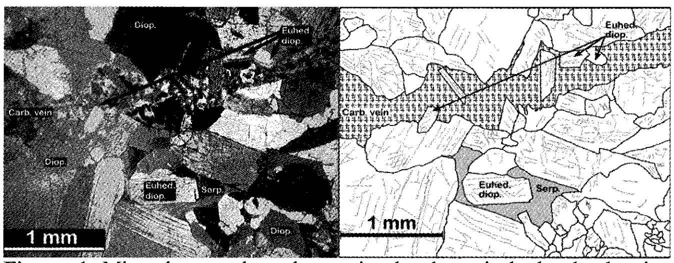

Figure 1 Microphotograph and associated schematical sketch showing ambiguous relationships between a carbonate vein and its host diopsides. Euhedral diopsides crystallizing within serpentine may also be seen.

Chemical characters are also distinct from those of other cumulates of Oman (see figure 3). In spite of their refractory

[a] marie@earth.s.kanazawa-u.ac.jp

[b] Georges.Ceuleneer@dtp.obs-mip.fr, URL: http://www.obs-mip.fr/umr5562/index.html

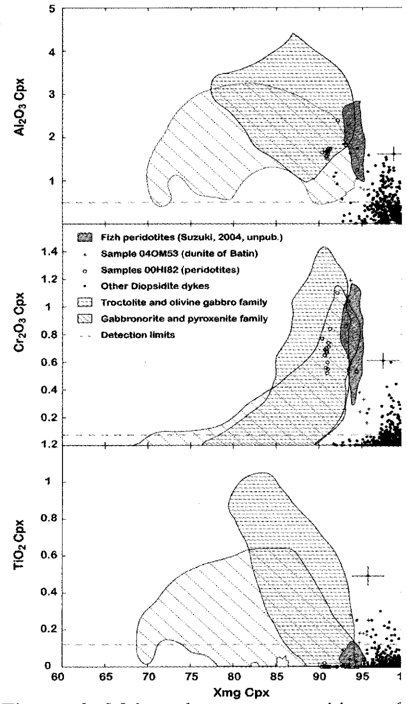

Figure 3 Major element composition of diopsidite dykes. Dashed surfaces show the compositional domain for the others kind of dyke (see Python and Ceuleneer, 2003) and the gray surface, the compositional domain for omanese peridotites. Solid circles: composition of diopsidite samples; open circles: composition of surrounding peridotite; black cross: chemistry of sample 04OM53 (dunite from Batin area). Detection limit and analytical error are given on each diagram.

composition, diopsides are strongly depleted in Cr (Cr_2O_3<0.2%). By the same way, other minor elements (Al, Ti, Na,...) have particularly low abundance and plot away from magmatic differentiation trends (figure 3). In a few samples, the paragenetic association includes pure anorthite (An% up to 99%) and minor amount of olivine which composition is close to the pure forsterite (Fo>95%). Olivine included at the rim of diopsidite dykes exhibit this refractory composition but, at thin section scale, becomes "normal" with composition similar to the one of other Oman harzburgites.

The distribution of these diopsidite dykes is not random on the surface of the Oman ophiolite, the higher abundance being found near to the former asthenospheric diapir emplaced at shallow depth in the lithosphere.

Recent studies in ophiolites and at mid-ocean ridges (Vanko and Laverne, 1998; Manning et al., 2000, Nicolas et al., 2003, Bosch et al., 2003) have shown that no clear thermal or chemical boundary exists between purely magmatic and purely hydrothermal processes. On the other hand, the presence of abundant orthopyroxenes in the crustal section in the Oman ophiolite (Benoit et al., 1999; Boudier et al., 2000) and at Mid-Atlantic ridge (Nonnotte et al., 2005) as well as their chemical and isotopic composition suggest that hydrothermal fluids may have penetrated down to the crust-mantle transition zone and interacted with the upper mantle. We interpret the diopsidites as the footprint of very high temperature (about 1000°C) circulations of seawater and carbonated fluids inducing some sort of prograde metamorphism of the surrounding serpentinized harzburgites and interacting in some way with melt that have originated from mantle diapir. Our data confirm all these observations and the prediction of McCollom and Shock (1998) who proposed that common anhydrous minerals like pyroxene, plagioclase and olivine may crystallize from high temperature fluids intermediate between silicate melts and supercritical water.

References

Benoit M., Ceuleneer, G. and Polvé, M., The remelting of hydrothermally altered peridotite at mid-ocean ridges by intruding mantle diapir. *Nature, 402*(6761), 514-518, 1999.

Boudier, F., Godard, M. and Ambruster C., Significance of gabbronorite occurrence in the crustal section of the Semail ophiolite. *Mar. Geophys. Res., 21*(3-4), 307-326, 2000.

Bosch, D., Jamais, M., Boudier, F., Nicolas, A., Dautria J.-M. and Agrinier P., Deep and high temperature hydrothermal circulation in the Oman ophiolite – Petrological and isotopic evidence. *J. Petrol., 45*(6), 1181-1208, 2004.

Mannig C.E., MacLeod, C.J., and Weston, P.E., Lower crustal cracking front at fast spreading ridges: evidence from the East Pacific Rise and the Oman ophiolite. In *Y. Dilek, E.M. Moores, D. Elthon and A. Nicolas (eds), Ophiolites and oceanic crust: New insights from field studies and the Ocean Drilling Program, GSA spec. publ. vol 349,* 261-272, doi: 10.1130/0-8137-2349-3, 2000.

McCollom, T.M. and Shock E., Fluid-rock interactions in the lower oceanic crust: Thermodynamic models of hydrothermal alteration. *J. Geophys. Res., 103*(B1), 547-575, 1998.

Python, M. and Ceuleneer, G., Nature and distribution of dykes and related melt migration structures in the mantle section of the Oman ophiolite. *Geochem. Geophys. Geosyst., 4*(7), 8612, doi: 10.1029/2002GC000354, 2003.

Nicolas, A., Mainprice, D., Boudier, F., High temperature seawater circulation throughout crust of oceanic ridges: A model derived from the Oman ophiolite. *J. Geophys. Res., 108*(B8), 2003.

Vanko, D.A. and Laverne C., Hydrothermal anorthization of plagioclase within the magmatic/hydrothermal transition at mid-ocean ridges: Exemples from deep sheeted dikes (Hole 504B, Costa-Rica Rift) and a sheeted dike root zone (Oman ophiolite). *Earth and Planet. Sci. Lett.,162*(1-4), 27-43, 1998.

Nonnotte, P., Ceuleneer, G. and Benoit, M., Genesis of andesitic-boninitic magmas at mid-ocean ridges by melting of hydrated peridotites: Geochemical evidence from DSDP Site 334 gabbronorites. *Earth Planet. Sci. Lett.,* 236(3-4), 632-653, 2005.